Radiation Pressure on Tunable Optical Metamaterials for Propulsion and Steering without Moving Parts

Completed Technology Project (2012 - 2015)

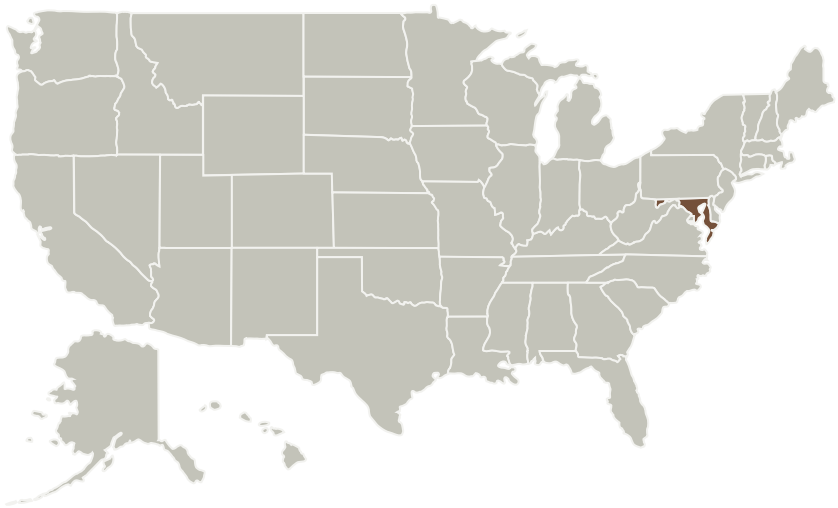
Project Introduction

Just as wind can exert a pressure on a sail to propel a sailboat, light too can exert a pressure on a reflective object. This radiation pressure can be used to propel small spacecrafts and is the working principle behind solar sails. However, in order to steer the craft, movable mechanical structures are usually needed, which is a major limitation due to added bulk and weight. In contrast to these traditional solar sails, we will use of a thin film optical metamaterial, composed of sub-wavelength resonant structures, which is capable of changing, in real-time, the optical properties of the device locally. This allows for active control of the resulting photon pressure and hence the ability to steer without the need for mechanically movable parts. In addition, by measuring the photon pressure, we will further illuminate the true nature of photon momentum—a controversy dating back to the early 1900s. We will determine the frequency dependence of the radiation pressure on a variety of materials (traditional dielectrics, traditional metals, and nano- and micro-structured metamaterials) using a cantilever-based setup.

Anticipated Benefits

In contrast to traditional solar sails, we will use of a thin film optical metamaterial, composed of sub-wavelength resonant structures, which is capable of changing, in real-time, the optical properties of the device locally. This allows for active control of the resulting photon pressure and hence the ability to steer without the need for mechanically movable parts. In addition, by measuring the photon pressure, we will further illuminate the true nature of photon momentum—a controversy dating back to the early 1900s.

Primary U.S. Work Locations and Key Partners



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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Organizations Performing Work	Role	Type	Location
University of Maryland-College Park(UMCP)	Supporting Organization	Academia	College Park, Maryland

Primary U.S. Work Locations
Maryland

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Project Management

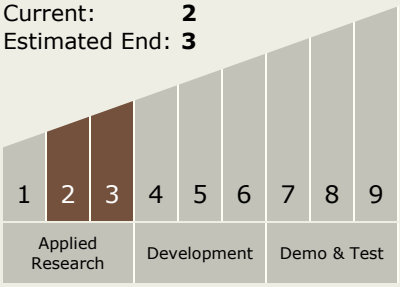
Program Director:
Claudia M Meyer

Program Manager:
Hung D Nguyen

Principal Investigator:
Jeremy Munday

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.4 Advanced Propulsion
    - TX01.4.1 Solar Sails